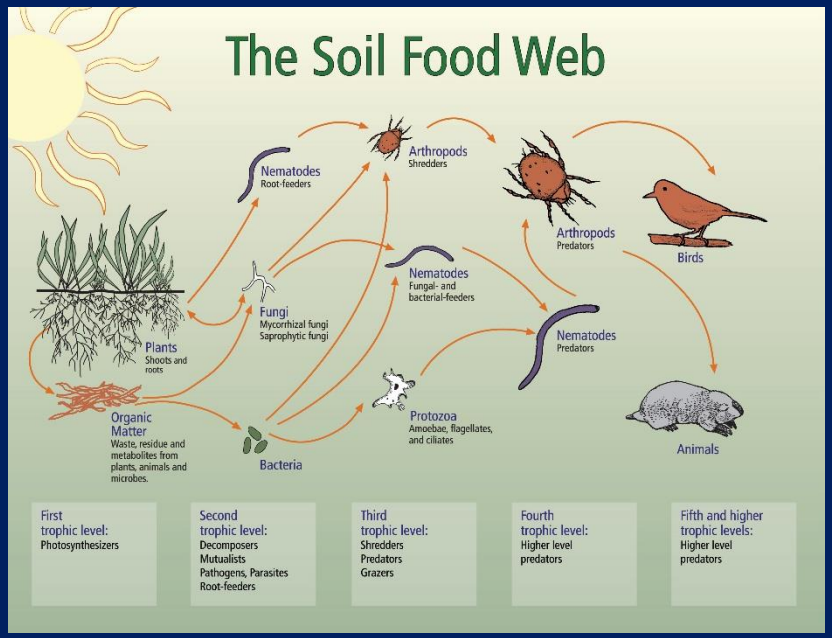
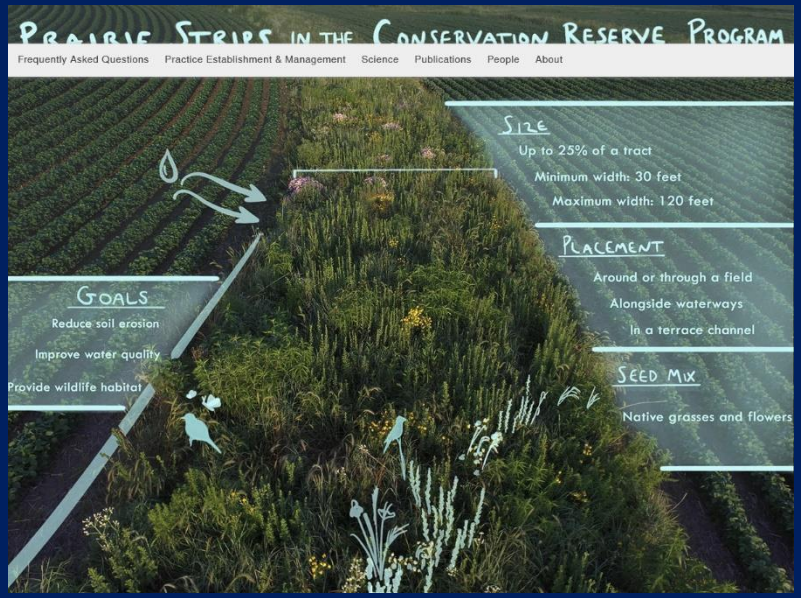
Whole Soil, Whole Farm, Whole Landscape:

A Whirlwind Tour of the Soil Health-Biodiversity Nexus





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I'M LOOKING FOR | VAAFM NEWS | FUNDING OPPORTUNITIES | VIDEO | EVENTS CALENDAR | EXPERIENCES

"The purpose of this Working Group (PES Working Group) is to recommend financial incentives designed to encourage farmers in Vermont to implement agricultural practices that improve soil health, enhance crop resilience, increase carbon storage and stormwater storage capacity, and reduce agricultural runoff to waters".

Select Language

PAYMENT FOR ECOSYSTEM SERVICES AND SOIL HEALTH WORKING GROUP

All Vermont Payment for Ecosystem Services and Soil Health Working Group (PES WG) meetings are open to the public, and will have public comment periods.

This webpage will be kept up to date with upcoming PES WG meeting schedules, agendas, and information on how to access each meeting. Materials related to each past meeting and agendas for upcoming meetings will be uploaded once available at PES WG Meetings and Materials. Webinars are held occasionally between meetings: recordings will be shared at PES Working Group Webinars.

To join an upcoming meeting, find the Agenda & Registration Link for the meeting on PES WG Meetings and Materials.

Upcoming meeting schedule:

We are holding our fall meetings via Zoom on **the first and third Tuesday of the month, from 12-2 PM**, beginning on September 21, 2021 and continuing into 2022.

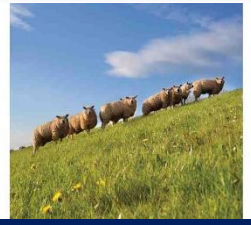
PES WG MEETINGS AND MATERIALS (INCLUDING AGENDAS & REGISTRATION LINKS)

Background on the PES Working Group

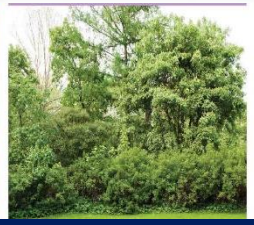
The Biodiversity Continuum and Its Metrics:

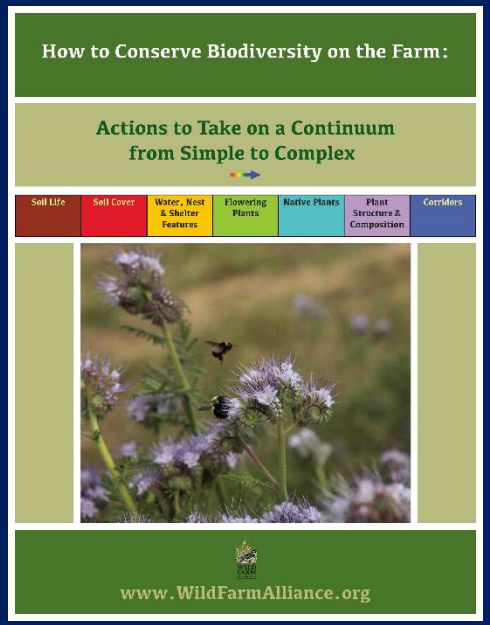
Actions to Take on a Continuum from Simple to Complex

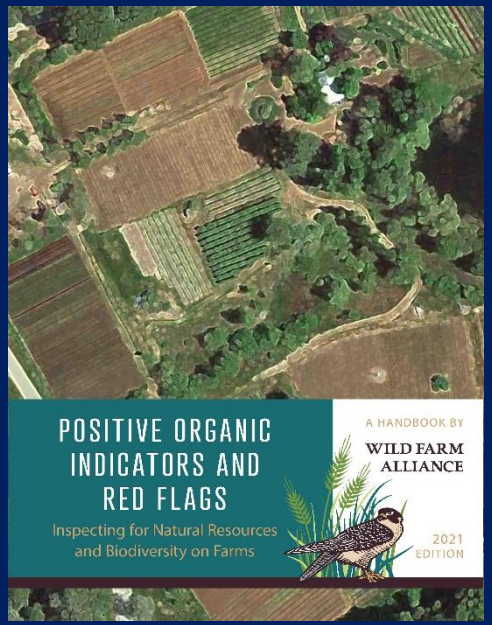
Soil Life	Soil Cover	Water, Nest & Shelter Features	Flowering Plants	Native Plants	Plant Structure & Composition	Corridors

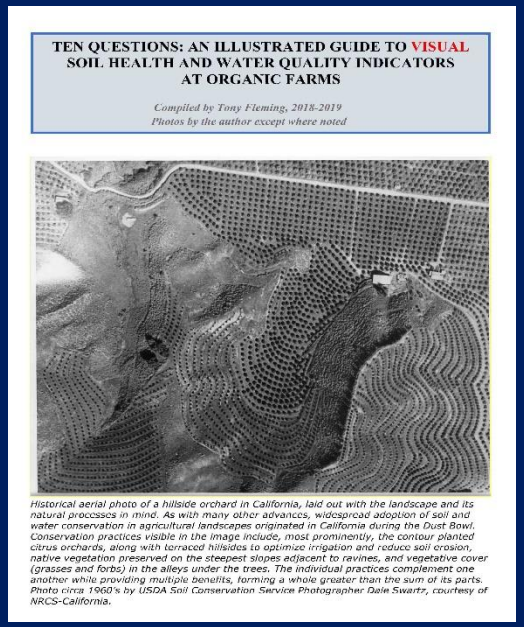





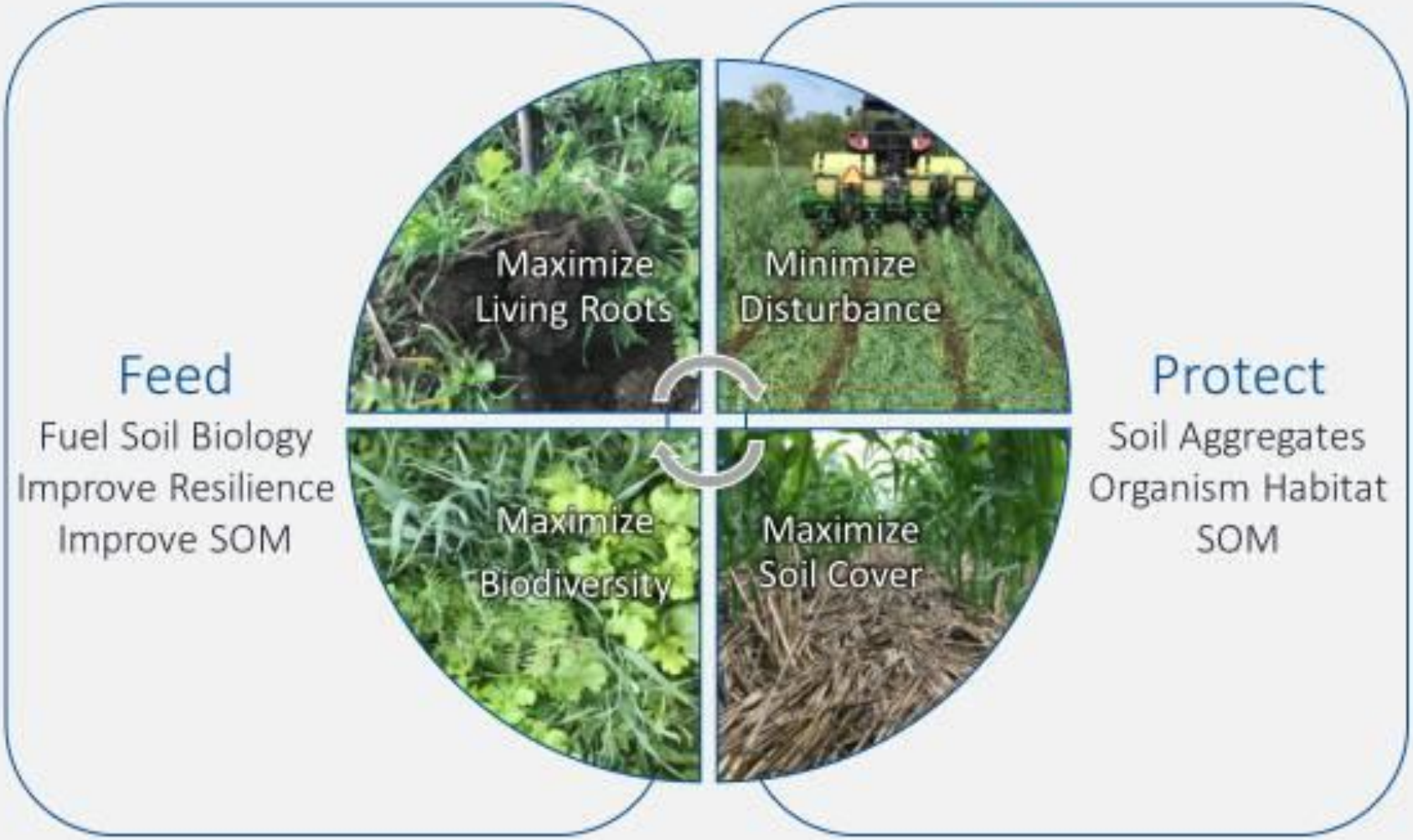






Soil Health Principles to Support High Functioning Soils

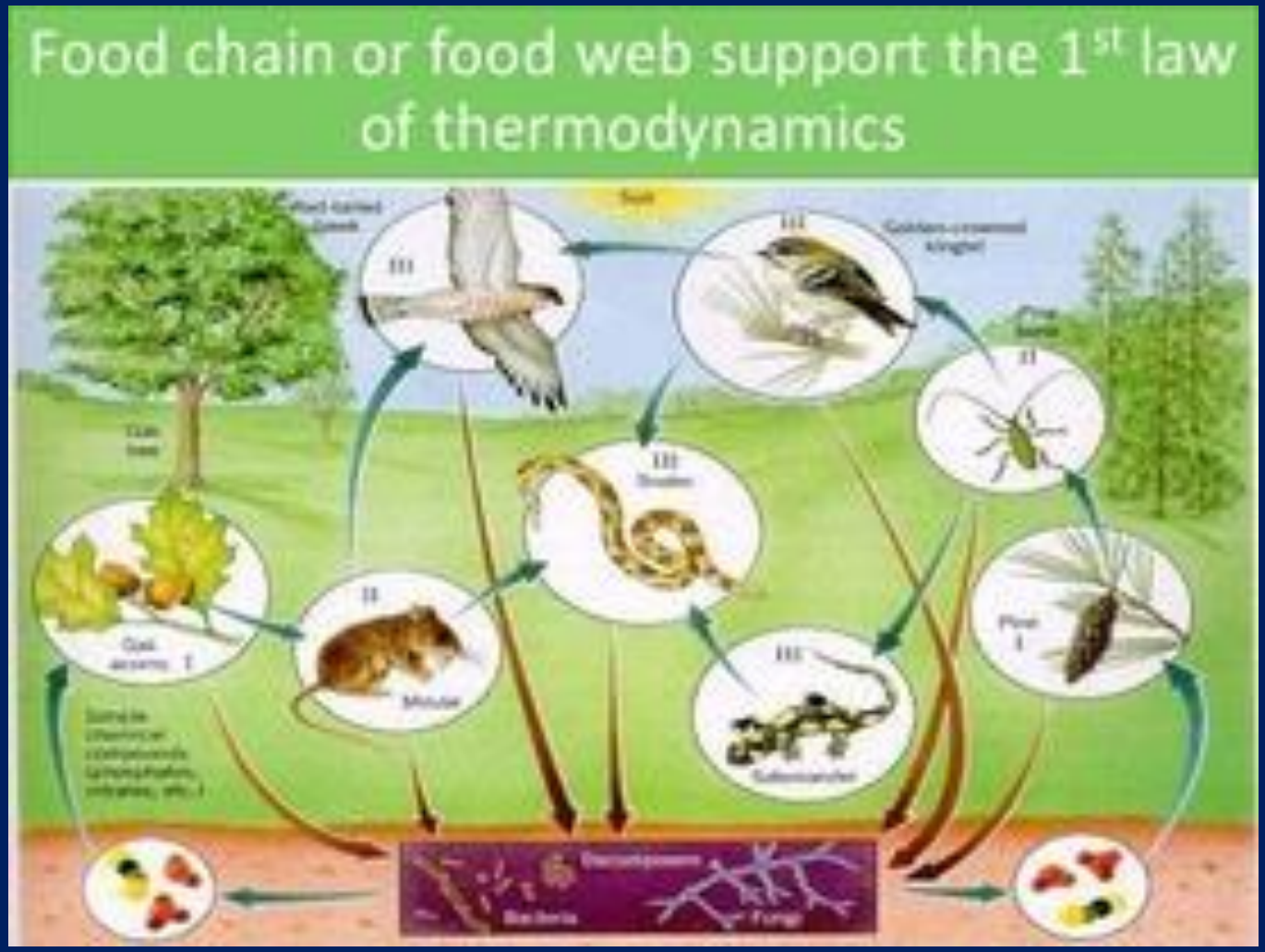


Soil Health Principles to Support High Functioning Soils

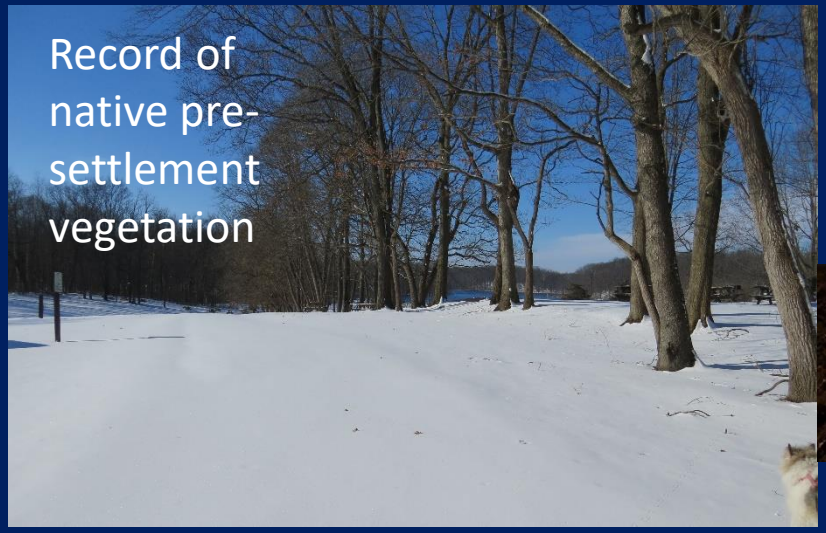
"The purpose of this Working Group (PES Working Group) is to recommend financial incentives designed to encourage farmers in Vermont to implement agricultural practices that:
improve soil health,
enhance crop resilience,
increase carbon storage
and stormwater storage capacity,
and reduce agricultural runoff to waters".

And mitigate the biodiversity crisis?

The 1st Law of Ecology: Everything Is Connected to Everything Else by the Flow of Energy Through Food Webs



Hedgerows: Repositories of Landscape Memory

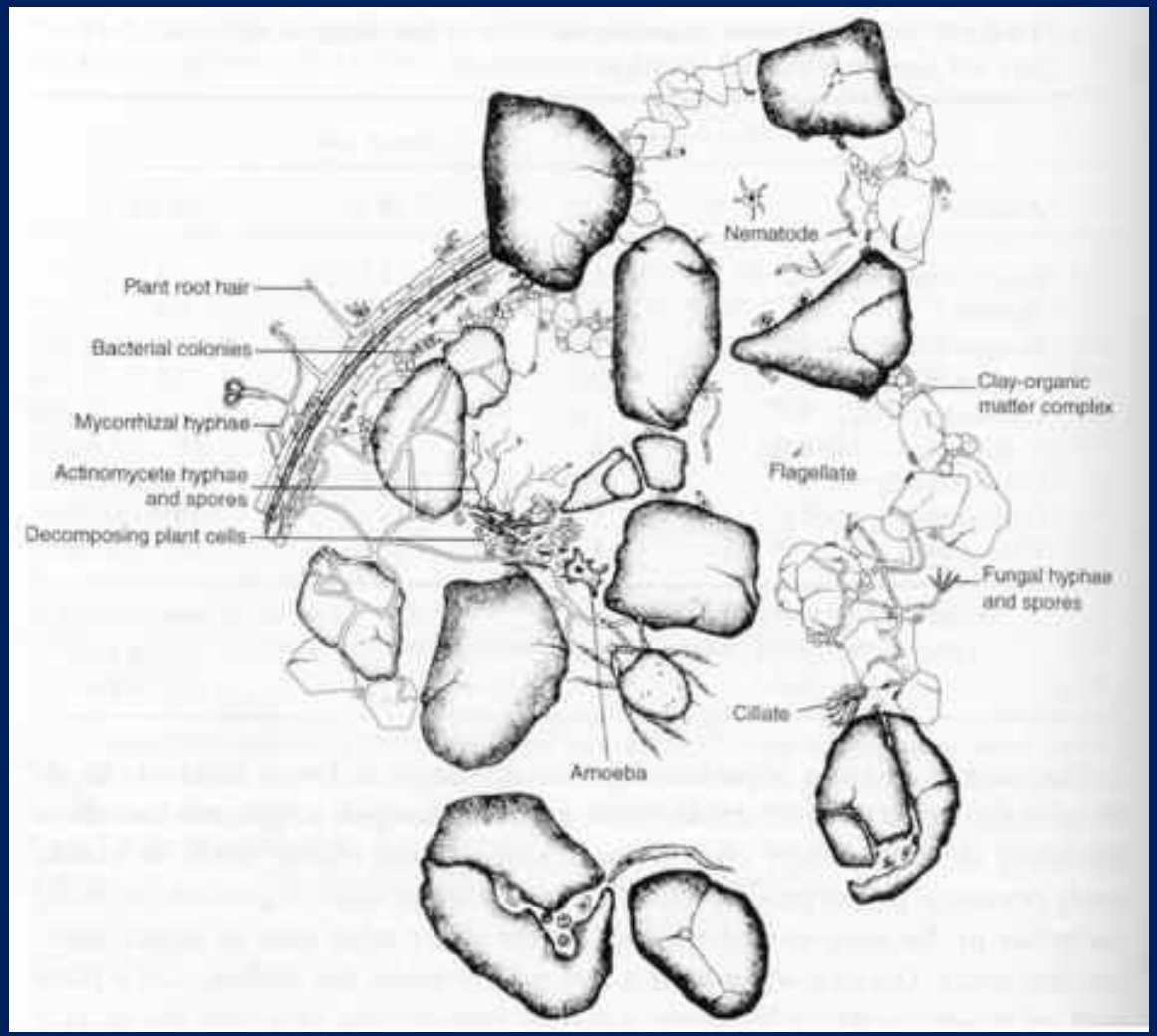


The best soil on most farms is found in the fence row.

These undisturbed remnants of what soil properties were once like is no surprise to farmers who have dug into that soil. It's crumbly, dark, and loose, and it's a model of soil structure and organic matter for farmers who are trying to make their soil healthier.

- USDA, Soil Health Nuggets

Fungal threads and other soil biota are the "glue" that hold soil aggregates together



PESTICIDES

New study: Agricultural pesticides cause widespread harm to soil health, threaten biodiversity

Most comprehensive review ever conducted of pesticide impacts on soil finds harm to beneficial invertebrates like beetles, earthworms in 71% of cases

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"...pesticides widely used in American agriculture pose a grave threat to organisms critical to healthy soil, biodiversity and soil carbon sequestration to fight climate change".

Frontiers in Environmental Science, 04 May 2021 | https://doi.org/10.3389/fenvs.2021.643847

Hedgerows: Pest Control Services

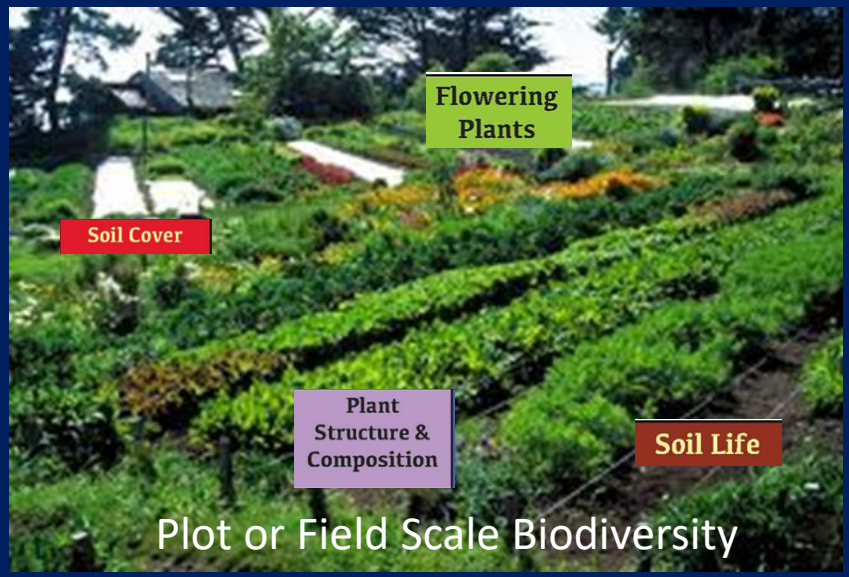
Flies are the #1 diet of several common species of predatory wasps

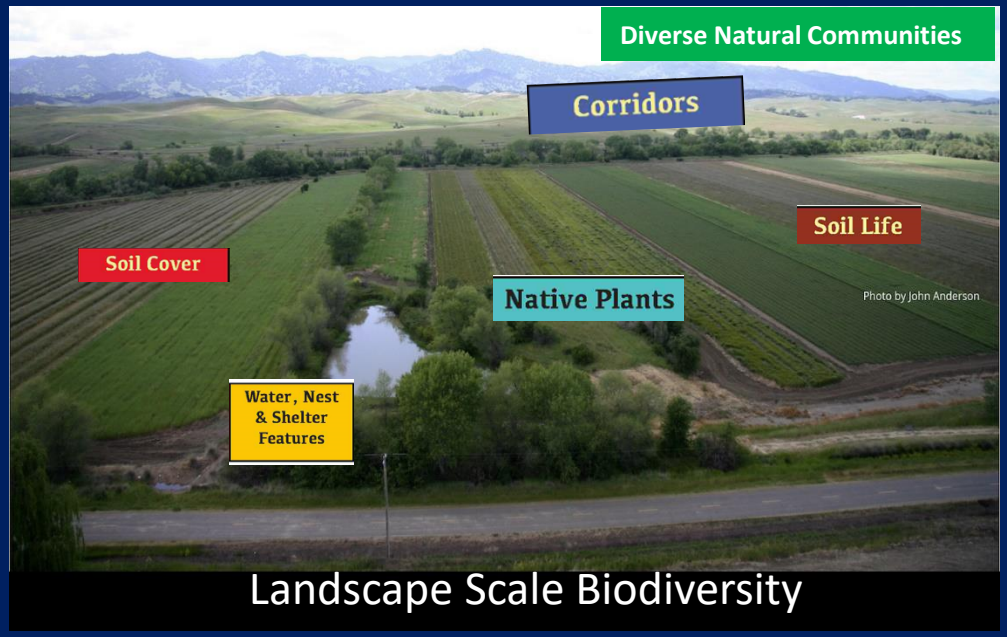
Biodiversity:

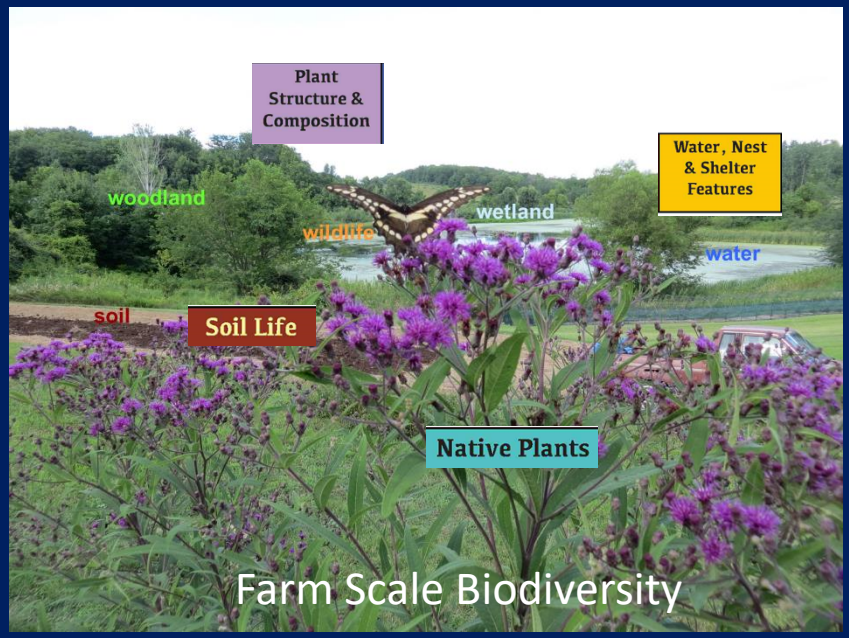
- includes variety in all forms of life from microbial organisms to flowering plants to animals.
- encompasses the diversity found at all levels of organization, from genetic differences between individuals and populations of a single species, to natural communities (ecosystems) composed of many species that interact via natural succession, predation, symbiosis, and many other processes.
- includes the full range of geophysical processes upon which the evolution and existence of life depend, such as surface processes and soil formation, the water cycle, nitrogen fixation, carbon and nutrient cycles, and many others

The Biodiversity Continuum in the Farm Landscape
Present at All Scales of Organization

Two key indicators of soil quality are structure and crop vigor. Soil under long-term organic management should exhibit a thick topsoil layer with excellent tilth (crumb structure, left) and robust root systems (right), independent of original soil texture. Whereas, the structure and crop vigor of soils under short- to medium-term organic management are typically more







Soil Health Practices: Significant Measurement Challenges

Quantitative Sampling and Measurements: More Expertise, Time, Money. Better Suited for Research Applications and Studies

Need A Waterway for Sampling and Measuring

How to Interpret in Muck/Peat Soils?

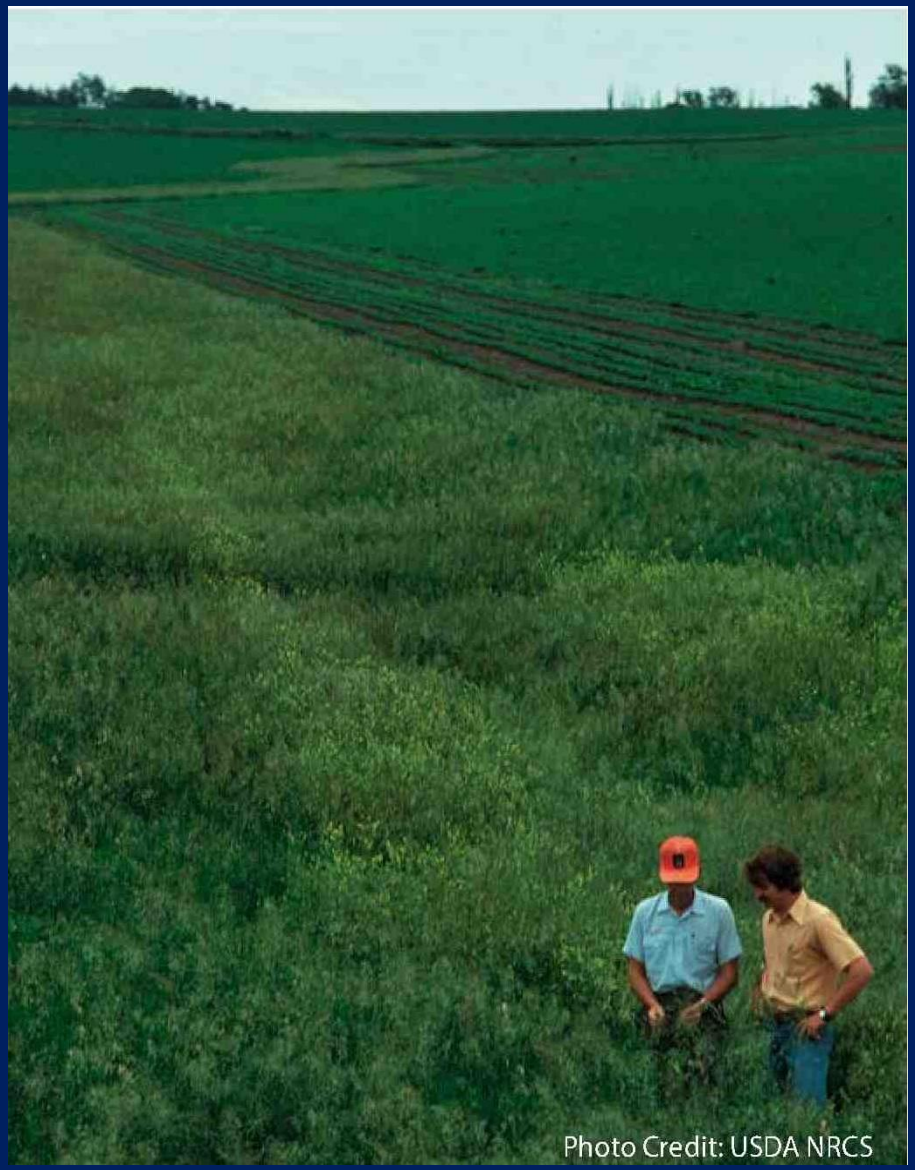
Best Observed in A Pit

Soil Respiration Test Kit

Qualitative Visual-Sensory Indicators: Simple. Fast. Inexpensive. Best for Farmers

Two key indicators of soil quality are structure and crop vigor. Soil under long-term organic management should exhibit a thick topsoil layer with excellent tilth (crumb structure, left) and robust root systems (right), independent of original soil texture. Whereas, the structure and crop vigor of soils under short- to medium-term organic management are typically more

To Succeed, You Have To Meet Farmers Where They Are On The Biodiversity Continuum



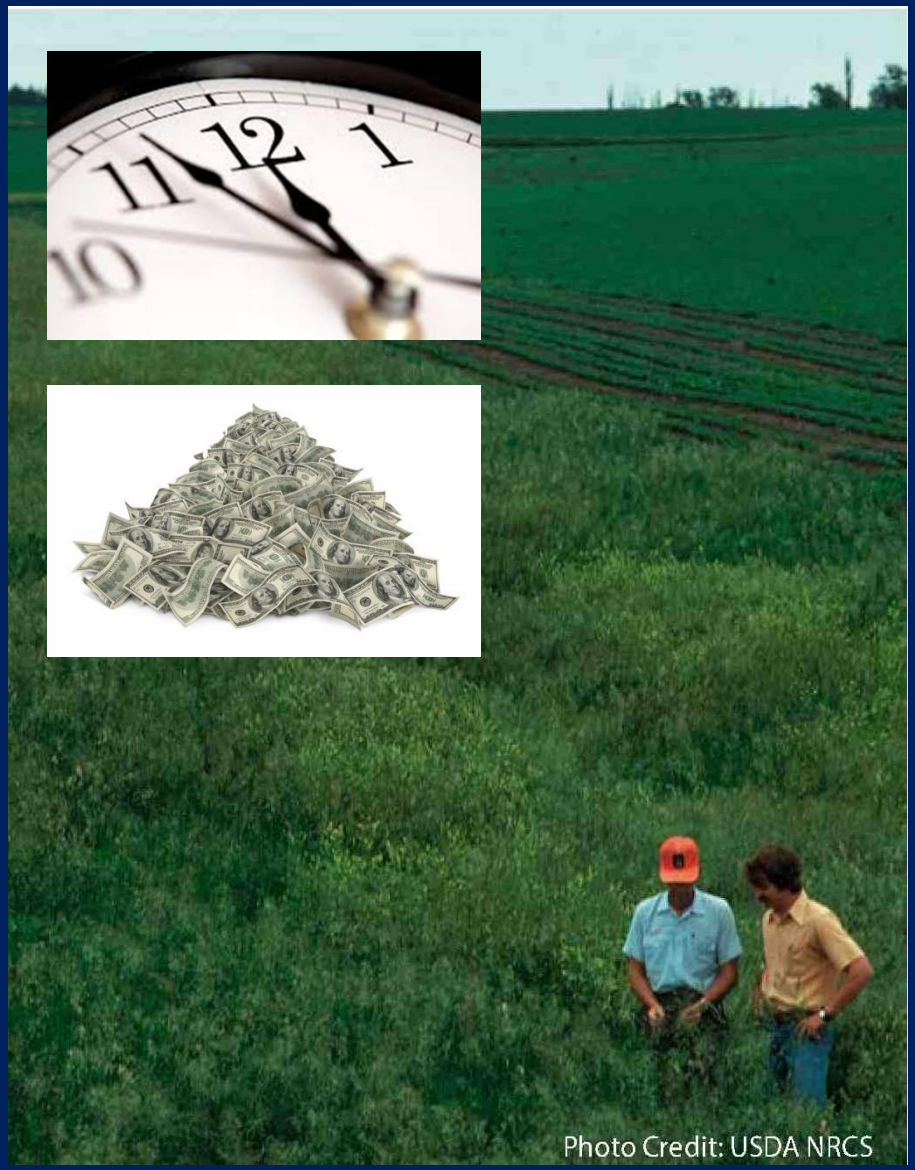
Learn how activities performed on the farm can take advantage of biodiversity and the benefits it provides. When moving along the continuum from the Simple to the Complex (brown to blue), biodiversity is increased on the farm.

CONTINUUM	SIMPLE activities to maintain biodiversity	---------->	---------->	---------->	---------->	---------->	COMPLEX activities to improve biodiversity
ECOLOGICAL PARAMETERS	Soil Life[2]	Soil Cover[2]	Water, Nest & Shelter Features	Flowering Plants	Native Plants	Plant Structure & Composition	Corridors

Step 1: Start with farm management on this page to assess activities across the continuum that work best for the situation and farm. Check boxes if activities are currently being used, and check circles if they are being planned.

Farm Management		Support diverse micro- and macro-organisms in the soil, especially near plant roots:		Keep soil covered as much as possible:		Reduce water use:		Use non-invasive, sequentially flowering plants that provide nectar and pollen:		Plant natives to support a wide variety of food, shelter and nesting sites:		Increase structural and compositional diversity with native trees (including snags and downed trees), shrubs, wildflowers, and grasses:		Create native plant corridors, especially along waterways and swales / Support watershed level restoration:
Annual crop	☐ ○	...by rotating crops, reducing tillage, or using cover crops, manure or compost	☐ ○	...with crops, cover crops or non-invasive plants / Allow non-invasive plants to grow along fences, roadways and in ditches / Use filter strips	☐ ○	...by planting crops appropriate for climate, and increasing soil organic matter and irrigation efficiency	☐ ○	...interspersed in crops, or at the ends of crop rows, or by retaining at any time, at least part of one field with a flowering crop or cover crop for each farm location	☐ ○	...in areas at the ends of crop rows, in prairie strips, hedgerows and windbreaks	☐ ○	...in crop perimeters, and in natural areas on the farm (riparian areas, wetlands, grasslands, shrublands and woodlands)	☐ ○	...by connecting farm habitat patches to natural areas on and off the farm
Perennial crop	☐ ○	...by using cover crops in understory	☐ ○	...with cover crops or with non-invasive plants in understory and along fences, roadways and ditches	☐ ○	...by planting crops appropriate for climate, and increasing soil organic matter and irrigation efficiency	☐ ○	...in understory	☐ ○	...in understory, buffer strips, hedgerows and windbreaks	☐ ○	...in crop perimeters, and in riparian areas, wetlands, grasslands, shrublands and woodlands on the farm	☐ ○	...by connecting farm habitat patches to natural areas on and off the farm
Pasture	☐ ○	...by managing mixed livestock with different grazing and soil impacts / Conserve natural grasslands	☐ ○	...by rotationally grazing and controlling access to sensitive areas, particularly riparian zones and wetlands	☐ ○	...by planting forage appropriate for climate, and increasing soil organic matter and irrigation efficiency	☐ ○	...interspersed in pastures	☐ ○	...interspersed in pastures, and in buffer strips, hedgerows and windbreaks	☐ ○	...interspersed in pastures, and in riparian areas, wetlands, grasslands, shrublands and woodlands on the farm	☐ ○	...by connecting pastures to natural areas on and off the farm

To Succeed, You Have To Meet Farmers Where They Are On The Biodiversity Continuum



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ARTICLES
https://doi.org/10.1038/s43016-021-00281-1
nature food
Check for updates

Landscape complexity and US crop production

Katherine S. Nelson [1,3] ✉ and Emily K. Burchfield [2,3]

Agricultural expansion and intensification have simplified Earth's landscapes, thereby adversely affecting the biodiversity and ecosystem services that support agricultural production. Field-scale research suggests that increased landcover complexity can improve crop productivity, but less is known about how complexity and crop productivity interact at broader landscape scales. This study evaluates the relationship between landscape complexity and crop yields for counties in the conterminous United States from 2008 to 2018. Our results suggest that the number and quantity of landcover categories on a landscape has a stronger influence on yields than how these landcover categories are arranged on the landscape. Specifically, increased landcover diversity is associated with yield increases for corn and wheat of more than 10%—an effect strength similar to the impact of seasonal precipitation and soil suitability. Notably, landscape configurations that are both moderately complex and also highly diverse are associated with yield increases of more than 20% for corn and wheat. Our findings suggest that increasing the complexity of landcover may provide a way to improve crop productivity in the United States without further extensification or intensification of agriculture.

-Analyzed corn and wheat yields vs. landscape complexity over a ten-year period for the entire US
-Number and quantity of landcover categories has a stronger influence on yields than how they are arranged
-Increased landcover diversity is strongly associated with yield increases of 10-20%. Similar to effects of soil fertility and precipitation

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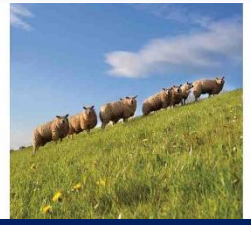
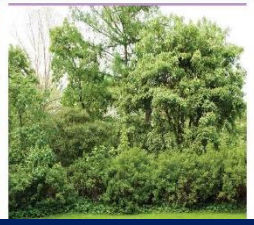
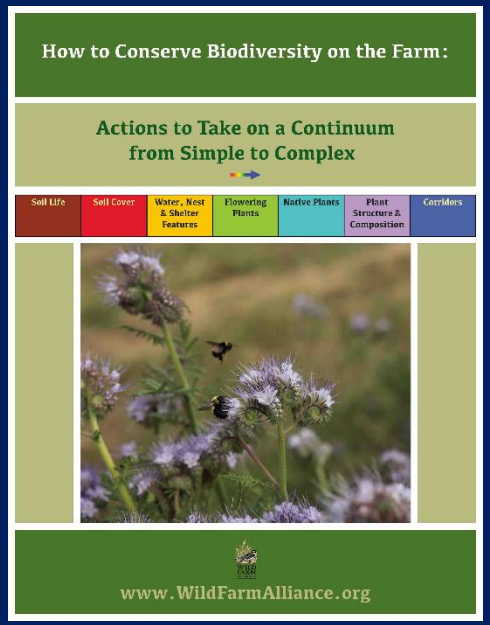
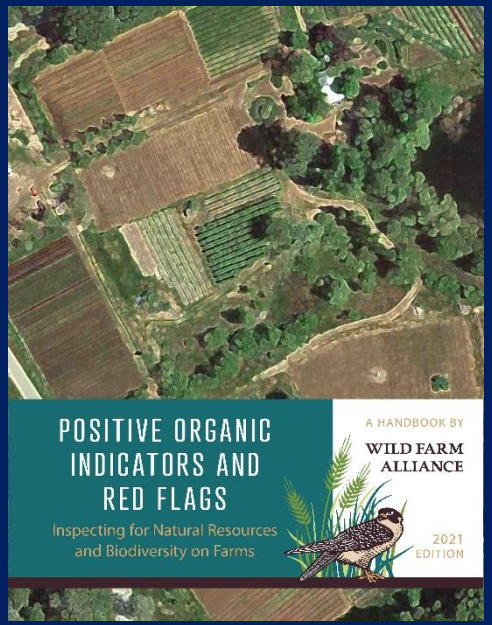
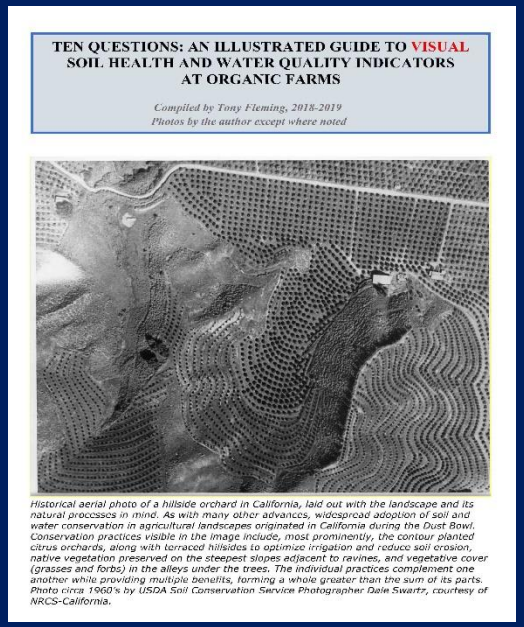






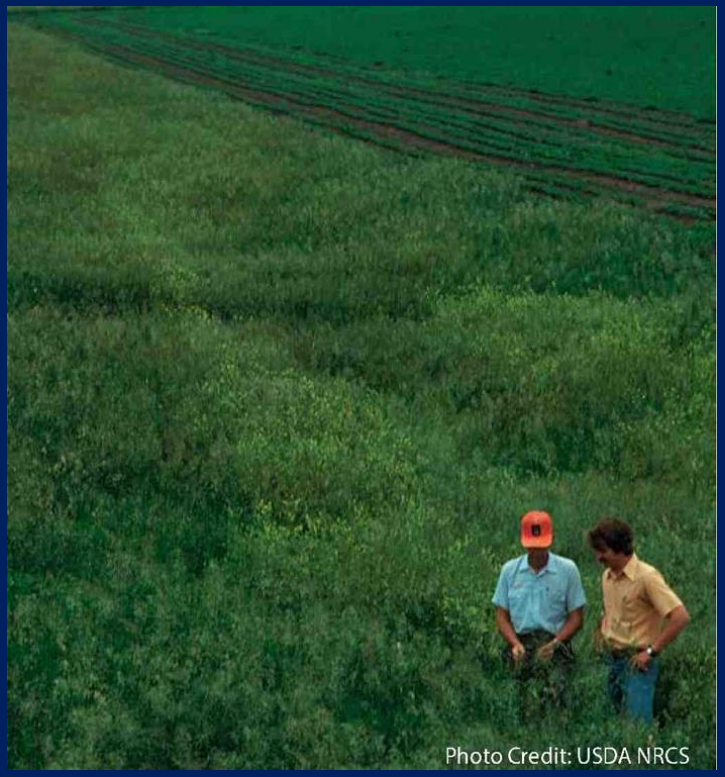







The Majority of Topsoil Loss from Agricultural Lands Occurs During Intense Rainstorms When Soil Is Bare or Nearly So

Ecological Service: Interception



Does Terminating Cover Crops With Herbicide Promote Soil Health?

PESTICIDES

New study: Agricultural pesticides cause widespread harm to soil health, threaten biodiversity

Most comprehensive review ever conducted of pesticide impacts on soil finds harm to beneficial invertebrates like beetles, earthworms in 71% of cases

A new study published recently by the academic journal *Frontiers in Environmental Science* finds that pesticides widely used in American agriculture pose a grave threat to organisms that are critical to healthy soil, biodiversity and soil carbon sequestration to fight climate change. Yet, those harms are not considered by U.S. regulators.

The study, by researchers at the Center for Biological Diversity, Friends of the Earth U.S., and the University of Maryland, is the largest, most comprehensive review of the impacts of agricultural pesticides on soil organisms ever conducted.

The researchers compiled data from nearly 400 studies, finding that pesticides harmed beneficial, soil-dwelling invertebrates including earthworms, ants, beetles and ground nesting bees in 71% of cases reviewed.

"It's extremely concerning that 71% of cases show that pesticides significantly harm soil invertebrates," said Dr. Tara Cornelisse, an entomologist at the Center for Biological Diversity and co-author of the study. "Our results add to the evidence that pesticides are contributing to widespread declines of insects, like beneficial predaceous beetles and pollinating solitary bees."

The findings come on the heels of a recent study published in the journal *Science* showing pesticide toxicity has more than dou-

CONTINUED ON PAGE 36 ▶

Crimping Mature Annual Rye

Field Edges: A Crucial Piece of the Farm Landscape

Hedgerows and Native Grasslands Offer A Multitude of Ecological Services

California Healthy Soils Program

Planting a Hedgerow Funded Through the California Healthy Soils Program

Journal of Economic Entomology Advance Access published May 11, 2016

Journal of Economic Entomology, 2016, 1–8
doi: 10.1093/jee/tow086
Research article

Apiculture & Social Insects

Pest Control and Pollination Cost–Benefit Analysis of Hedgerow Restoration in a Simplified Agricultural Landscape

L. A. Morandin,[1] R. F. Long,[2,3] and C. Kremen[4]

[1]Ecological Consulting, Victoria, BC, Canada (lora.morandin@gmail.com), [2]University of California Cooperative Extension, 70 Cottonwood St., Woodland, CA 95695 (rflong@ucanr.edu), [3]Corresponding author, e-mail: rflong@ucanr.edu, and [4]Department Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720 (ckremen@berkeley.edu)

Strongly positive cost-benefit ratio for hedgerow ecological services. Payback in as little as 7 years

"Riparian and hedgerow habitats with woody vegetation stored 18% of the farmscape's total carbon (C), despite occupying only 6% of the total area. Infiltration rates in the riparian corridor were >230% higher than those observed in the production fields, and concentrations of dissolved organic carbon (DOC) in soil solution were as much as 65% higher".

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available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Biodiversity and multiple ecosystem functions in an organic farmscape

S.M. Smukler[a], S. Sánchez-Moreno[c], S.J. Fonte[d], H. Ferris[e], K. Klonsky[f], A.T. O'Geen[b], K.M. Scow[b], K.L. Steenwerth[g], L.E. Jackson[b,*]

What Does the Water Look Like Where The Stream Enters and Leaves the Farm???

Do Livestock Have Unlimited Access to Waterbodies?

How Is Manure Managed? And Where in Relation to Waterbodies?

How many times have you seen this – manure piled outside the barn on sloping ground, with no cover or containment, where it can easily run off downhill into waterways or production areas? In this case, the manure pile has been there for years – the bottom of the pile is very old, while the top is fresh – leaching nutrients and pathogens into the environment. All it takes is a small gully or rivulet to carry these constituents directly into a nearby stream anytime it rains hard. This is not "management" – it is a disposal system – and is a definite red flag for inspectors.

Obviously, the best disposition for manure is to have it deposited directly in healthy, biologically active pastures by the livestock. But the need to remove manure from unwanted locations is a fact of life on every livestock operation, even the most dedicated grass-based ones. If the operation is generating or using manure, then a complete assessment of manure management must consider all stages of the process and involves several related questions. For transport, the main question is whether and how much manure "leaks" into the general environment (roads, non-production areas, waterways, etc) during transport. Such leakage needs to be minimized – even small amounts of manure can turn a pond green with algae. For manure storage, the key question is whether it is stored in a way that minimizes runoff.

Pads (left), bunkers (center), and covers (right) are all proven methods of curtailing runoff from manure storage areas. Structures and management practices aimed at helping producers manage manure are eligible for a variety of state and federal financial incentives and technical assistance programs. Photo credits: NRCS

Do Livestock Have Unlimited Access to Waterbodies? What Do The Streambanks Look Like?

Livestock express natural social behaviors that emulate ancient migratory patterns of native graziers and exist in balance with water bodies and other natural resources

Farmer-Driven Soil and Whole-Farm Health Indicators

The Inspectors Report, Spring 2012

Fumbling Towards Complexity, Part III: Postcards from the Edge (of the Farm)

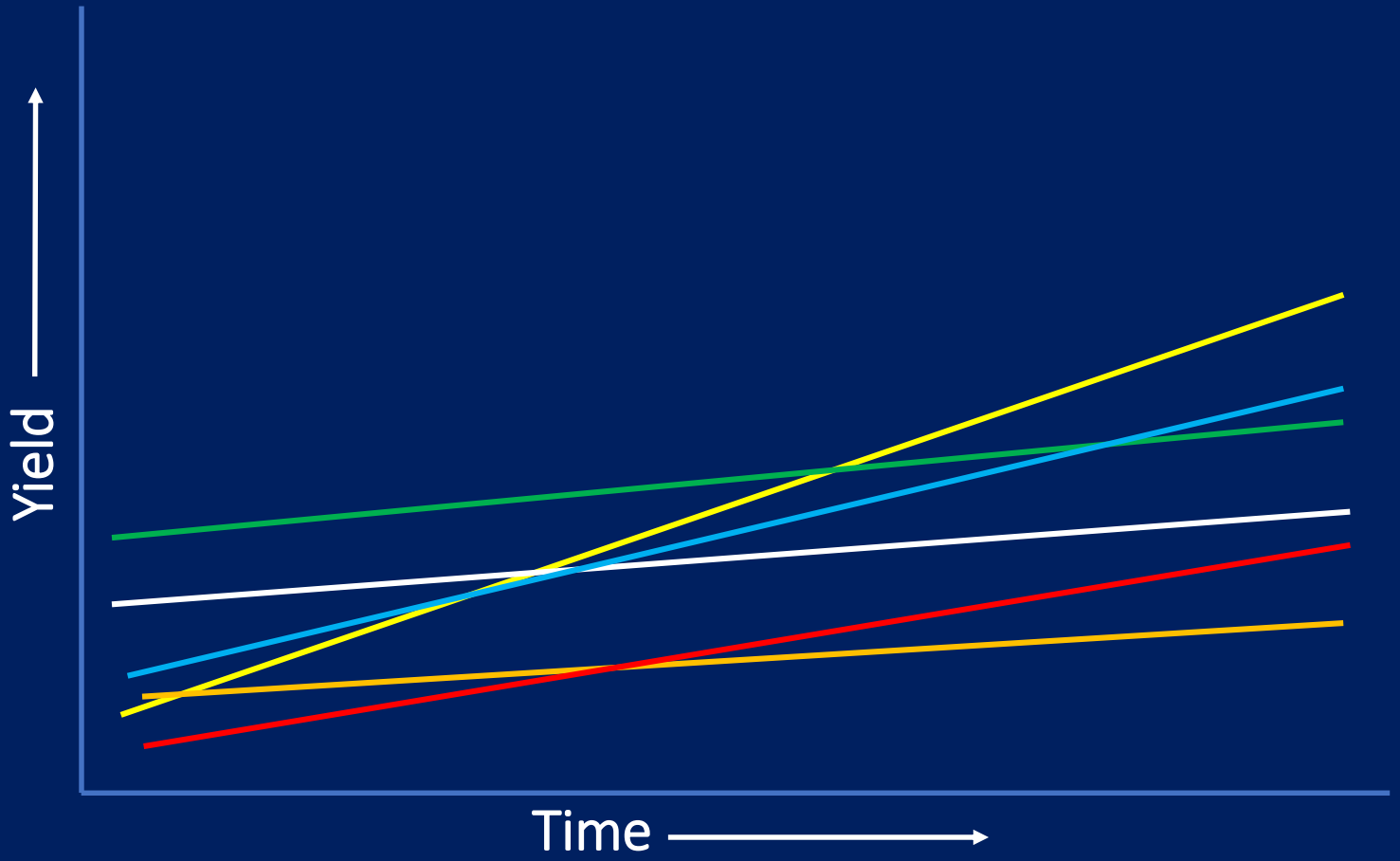
by Tony Fleming

(Ed. note-this is the third in an occasional series examining the role of natural resources in the certification process, and exploring some of the practical and institutional challenges that hinder inspectors' ability to assess and interpret biodiversity management on NOP-certified farms. Part I: A Brief Review of Biodiversity in the Certification Process--History, Assessment, and Institutional Imperatives appeared in the Winter 2011 newsletter, and Part II: The NOP Rule Requires Producers To Maintain or Improve the Natural Resources of the Operation—So What Measuring Stick Do Inspectors Use to Evaluate This Requirement?) appeared in the Spring, 2011 issue.

Imagine this: As you arrive for a farm inspection, your eye is drawn to the colorful border of a nearby field. You've been anticipating this visit since you first saw the unusually detailed farm map, which depicts features with intriguing names like "Heron's Roost" and "Seven Mile Swamp". Besides, any day spent along the third coast is a good day and a welcome reprieve from the monotony of square farms inland that occupy the vast, nature-challenged region of middle America known as the corn belt. Approaching the farmhouse, you pass a series of small raised beds—a child's garden—herbs in one; a cutting garden in another; giant

- 300-Acre Diversified Farm located in an environmentally sensitive area near Lake Michigan
- ¼ of the farm in natural areas: forest, wetlands, large creek
- No Inputs Other Than Seeds
- Long rotation with major intervals of alfalfa and other cover crops

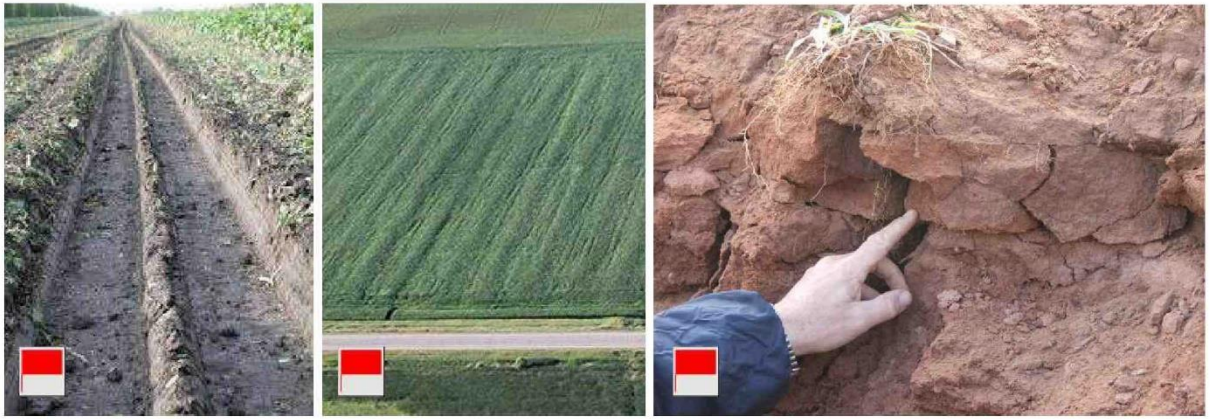
Consistent Recording of Yields Over Decades



Simple Tools to Assess Soil Health: Soil Probe, Tile Finder, Jar of Water, Magnifying Glass

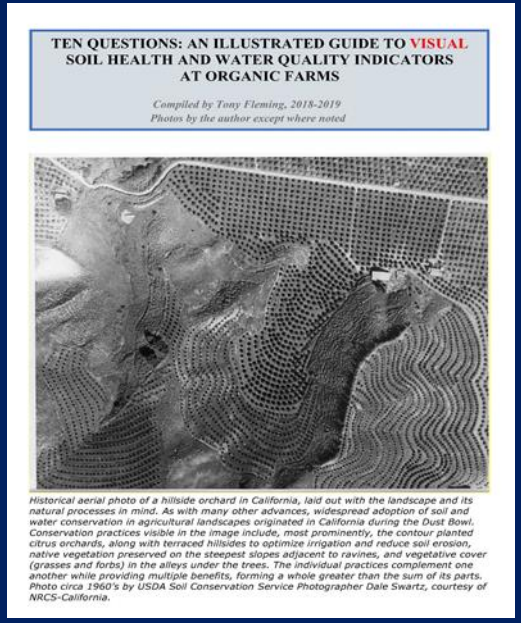
- Dialed in on finding and remediating areas of soil compaction, which causes reduced or declining yields and poor water infiltration

Soil Compaction: Silent Soil Killer



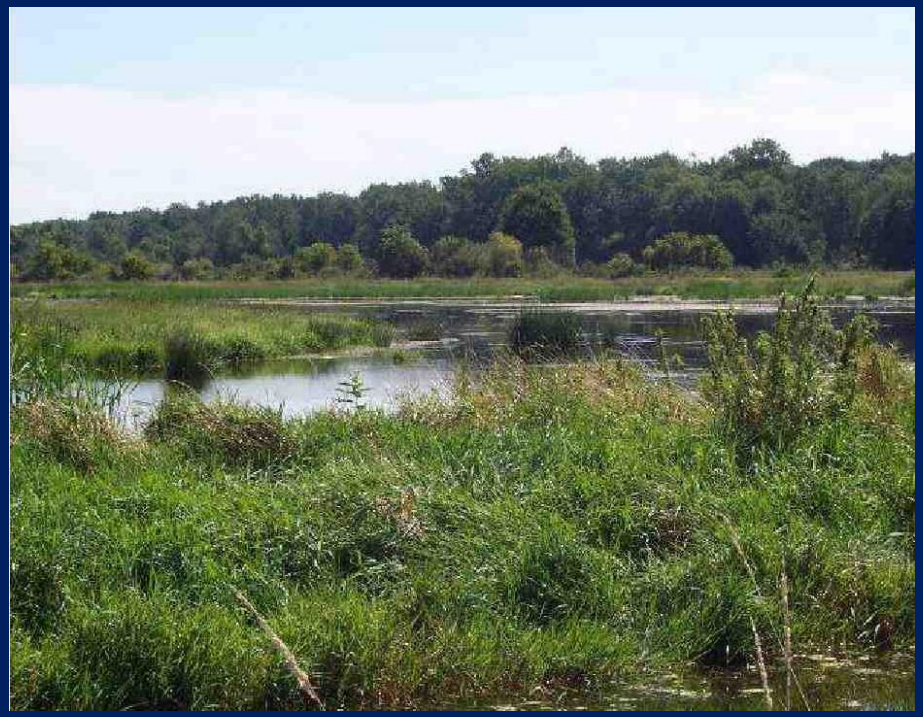
Compaction is seldom so evident in the field as in the left hand image. It can sometimes be identified in aerial imagery (center) by a consistent pattern of alternating stripes of vigorous and stunted crops that parallel wheel tracks. Compaction may affect the topsoil, the subsoil, or some combination, but it is often focused in a particular soil layer that is more susceptible than those above and below (right). A rigid probe is the best way to detect compaction from the surface and will penetrate a compacted layer only with great difficulty. Photo credits: left, Minnesota Dept. of Agriculture; center and right - Western Australia Ministry of Agriculture.

If compaction is hard to recognize, it is even more difficult to reverse. Proven methods include subsoiling (left) and long-term use of cover crops with deep, aggressive root systems like sorghum-sudangrass and cereal rye (right). The rye in the photo is about 1.5 m high, and its root system extends to a comparable depth. Regular cover cropping also is a proven method of preventing compaction because it increases and strengthens soil structure. Left photo credit – Western Australia Ministry of Agriculture.



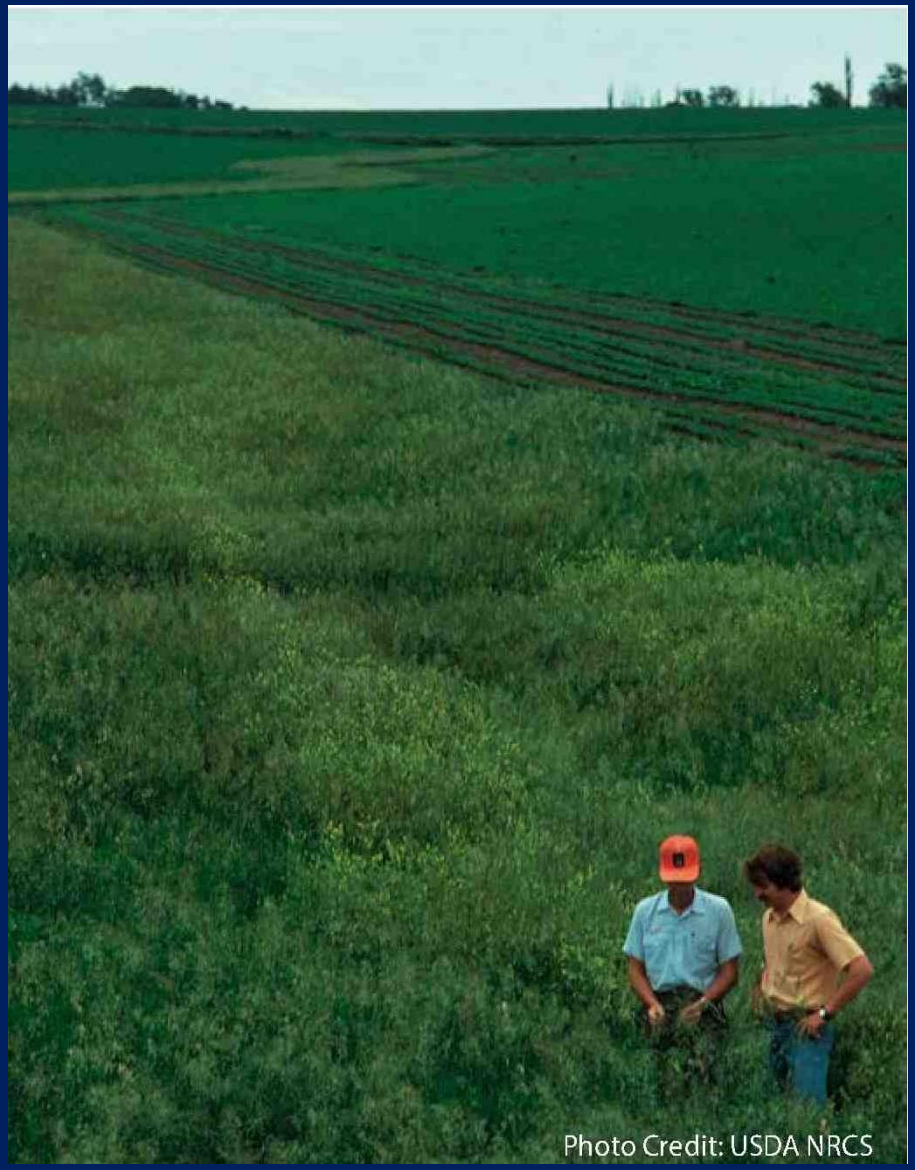
From: An Illustrated Guide to Visual Soil and Water Quality Indicators

Some Places Are Just Too Wet To Farm



Some farmers have the wisdom to accept this reality and restore the original wetlands

In the biodiversity continuum, simple in-field and edge-of-field soil health practices make up the core of the program. More complex ones can be added over time



Learn how activities performed on the farm can take advantage of biodiversity and the benefits it provides. When moving along the continuum from the Simple to the Complex (brown to blue), biodiversity is increased on the farm.

CONTINUUM	SIMPLE activities to maintain biodiversity	---------->	---------->	---------->	---------->	---------->	COMPLEX activities to improve biodiversity
ECOLOGICAL PARAMETERS	Soil Life[2]	Soil Cover[2]	Water, Nest & Shelter Features	Flowering Plants	Native Plants	Plant Structure & Composition	Corridors

Step 1: Start with farm management on this page to assess activities across the continuum that work best for the situation and farm. Check boxes if activities are currently being used, and check circles if they are being planned.

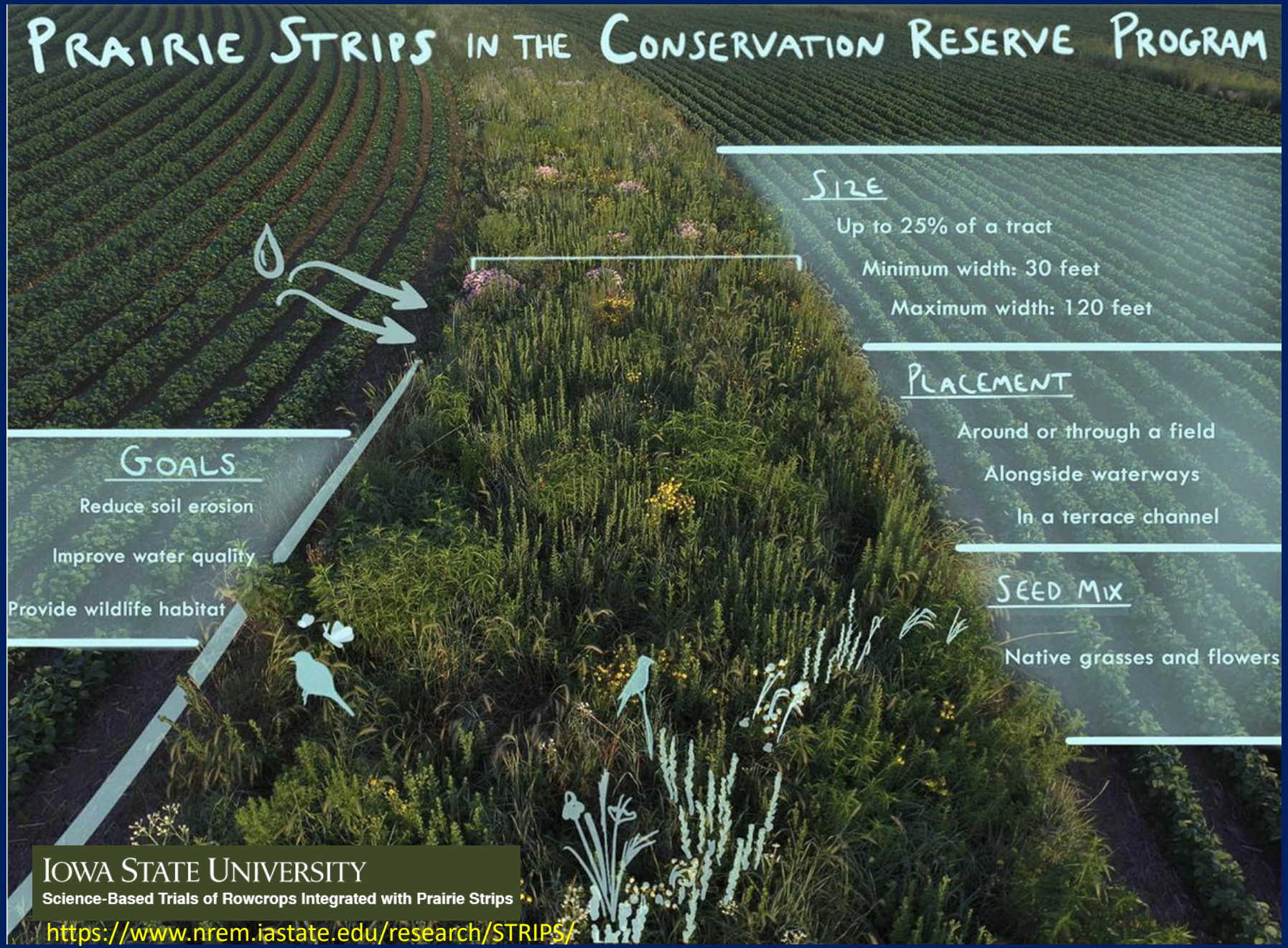
Farm Management		Support diverse micro- and macro-organisms in the soil, especially near plant roots:		Keep soil covered as much as possible:		Reduce water use:		Use non-invasive, sequentially flowering plants that provide nectar and pollen:		Plant natives to support a wide variety of food, shelter and nesting sites:		Increase structural and compositional diversity with native trees (including snags and downed trees), shrubs, wildflowers, and grasses:		Create native plant corridors, especially along waterways and swales / Support watershed level restoration:
Annual crop	☐ ○	...by rotating crops, reducing tillage, or using cover crops, manure or compost	☐ ○	...with crops, cover crops or non-invasive plants / Allow non-invasive plants to grow along fences, roadways and in ditches / Use filter strips	☐ ○	...by planting crops appropriate for climate, and increasing soil organic matter and irrigation efficiency	☐ ○	...interspersed in crops, or at the ends of crop rows, or by retaining at any time, at least part of one field with a flowering crop or cover crop for each farm location	☐ ○	...in areas at the ends of crop rows, in prairie strips, hedgerows and windbreaks	☐ ○	...in crop perimeters, and in natural areas on the farm (riparian areas, wetlands, grasslands, shrublands and woodlands)	☐ ○	...by connecting farm habitat patches to natural areas on and off the farm
Perennial crop	☐ ○	...by using cover crops in understory	☐ ○	...with cover crops or with non-invasive plants in understory and along fences, roadways and ditches	☐ ○	...by planting crops appropriate for climate, and increasing soil organic matter and irrigation efficiency	☐ ○	...in understory	☐ ○	...in understory, buffer strips, hedgerows and windbreaks	☐ ○	...in crop perimeters, and in riparian areas, wetlands, grasslands, shrublands and woodlands on the farm	☐ ○	...by connecting farm habitat patches to natural areas on and off the farm
Pasture	☐ ○	...by managing mixed livestock with different grazing and soil impacts / Conserve natural grasslands	☐ ○	...by rotationally grazing and controlling access to sensitive areas, particularly riparian zones and wetlands	☐ ○	...by planting forage appropriate for climate, and increasing soil organic matter and irrigation efficiency	☐ ○	...interspersed in pastures	☐ ○	...interspersed in pastures, and in buffer strips, hedgerows and windbreaks	☐ ○	...interspersed in pastures, and in riparian areas, wetlands, grasslands, shrublands and woodlands on the farm	☐ ○	...by connecting pastures to natural areas on and off the farm

The Low Hanging Fruit Principle: Target Areas or Watersheds Where the Need is Greatest

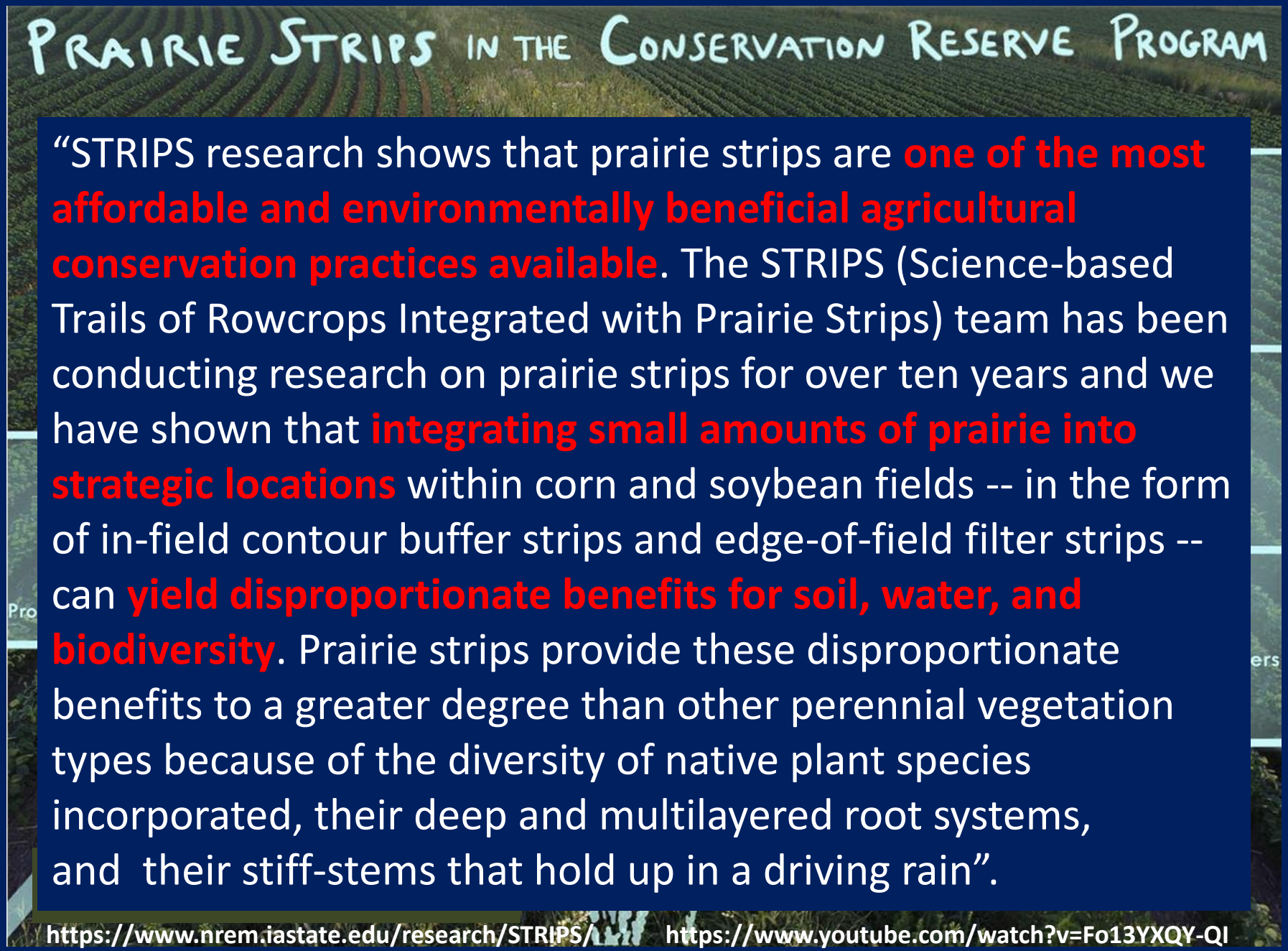
Just <u>one</u> poorly managed field or impaired agricultural tributary can account for most of the sediment and nutrient loading of a watershed

Convex slopes are another good target. Water runs off of them more readily, leading to lower soil quality due to less infiltration of water and shallower soil profiles, along with greater rates of topsoil erosion,

Prairie Strips: Soil Health Practice With Multiple Benefits



Prairie Strips: Soil Health Practice With Multiple Benefits



"STRIPS research shows that prairie strips are **one of the most affordable and environmentally beneficial agricultural conservation practices available**. The STRIPS (Science-based Trails of Rowcrops Integrated with Prairie Strips) team has been conducting research on prairie strips for over ten years and we have shown that **integrating small amounts of prairie into strategic locations** within corn and soybean fields -- in the form of in-field contour buffer strips and edge-of-field filter strips -- can **yield disproportionate benefits for soil, water, and biodiversity**. Prairie strips provide these disproportionate benefits to a greater degree than other perennial vegetation types because of the diversity of native plant species incorporated, their deep and multilayered root systems, and their stiff-stems that hold up in a driving rain".

https://www.nrem.iastate.edu/research/STRIPS/ https://www.youtube.com/watch?v=Fo13YXQY-QI